California Air Resources Board's
Emissions Inventory Series

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The Federal Test Procedure & Unified Cycle

Driving Cycles—Models of Driving Behavior

One of the fundamental assumptions underlying on-road emissions inventory development is that driving behavior can be captured and reproduced in a laboratory setting.

The Federal Test Procedure or FTP was developed in the late 1960 and early 1970's as a model of a typical commute in an urban area.

Neither Federal nor typical, the FTP was actually the composite of several "figure 8" trips to and from the then headquarters of the Air Resources Board in Downtown Los Angeles (See Map on Page 2).

When first utilized, the FTP or CVS72, was a two mode or two bag test. The term "bag" refers to the Tedlar bags in which exhaust is stored for analysis.

The first mode of the test is referred to as a "cold start" and includes the cranking or starting emissions of a vehicle which has been sitting overnight. This mode is 505 seconds in duration with a maximum speed of 56.7 miles per hour and an average speed of 25.6 miles per hour. The maximum acceleration and deceleration rates of 5.6 and 5.2 miles per hour per second were mitigated to 3.3 miles per hour per second because of the limitations of the belt driven dynamometers used at that time.

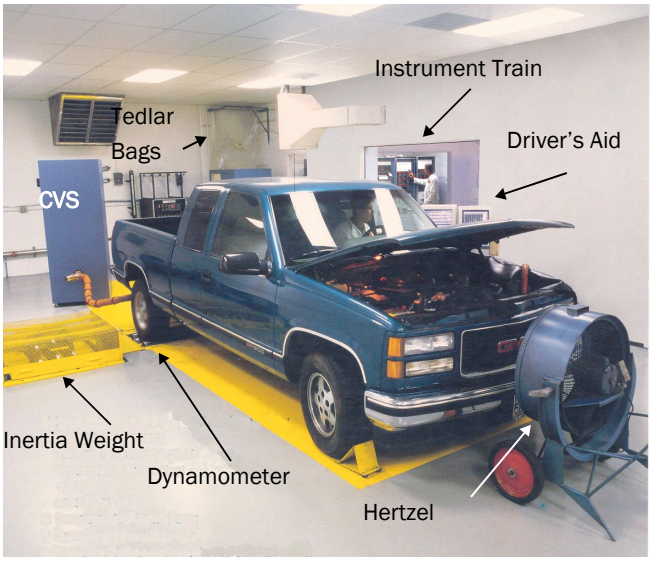
Mode two, or bag two, of the FTP is referred to as the "hot stabilized" portion of the test. With a maximum speed of 34 miles per hour and an average speed of 16, bag two is slower than bag one because bag one contains freeway driving. Again the maximum and minimum acceleration and deceleration rates of 5.4 and 8.0 miles per hour per second were clipped at plus or minus 3.3 miles per hour per second.

Taken together, the two modes of the CVS72 comprise a driving cycle which is 1,372 seconds in duration with an average speed of 19.6 miles per hour.

The CVS75 cycle added a third mode to the test. Upon completion of bag2, the vehicle is switched off and allowed to sit or soak for ten minutes after which the vehicle is restarted and mode one of the test is repeated. This is referred to as the hot start portion of the test.

Around 1990, inventory development staff began to question whether the FTP, which was over 15 years old, adequately represented contemporary driving. A research project was begun to develop an inventory specific cycle on which to base emission rates.

Traditionally, there are four methods of determining typical driving behavior. After selecting a frequently traveled route, the first method utilizes a "float" car approach. The float car is instrumented to record its own speed and the driver simply "floats" along with traffic.

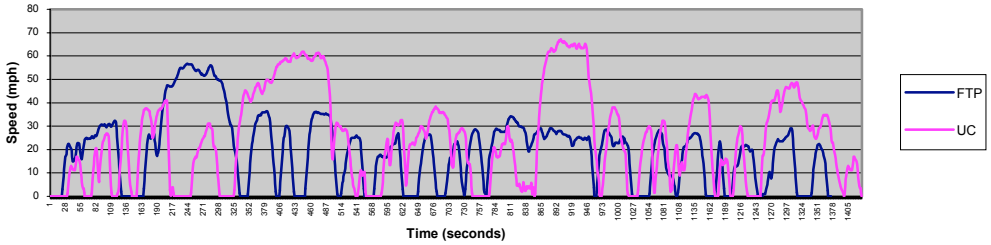


As with the float car, the "Chase" car approach uses a car instrumented to record its own speed but the driver follows one or more vehicles across the route attempting to mimic their driving behavior.

The third approach utilizes a chase car with a forward looking laser. By "locking on" to the vehicle being chased, the laser provides information on the difference between the speed of the target vehicle and that of the chase car.

The final approach involves the instrumentation of randomly selected vehicles with data collection devices capable of recording when, where and how the vehicle is being driven.

FTP and UC Speed vs Time Trace



The FTP and Unified Cycles

In 1992, with the help of the California Department of Transportation, CALTRANS, and the Southern California Association of Governments, SCAG, ARB staff identified the 102 most frequently traveled routes in the South Coast Air Basin.

ARB's contractor then used a chase car with a forward looking laser to record the driving patterns of randomly selected vehicles being driven over these routes.

Analyses of the resulting data showed that the FTP does not adequately cover typical driving patterns in the Los Angeles area.

To develop a more contemporary driving cycle for inventory purposes, all of the chase car data were aggregated to develop a target Speed - Acceleration Frequency Distribution model referred to as a "SAFD" or Watson Plot.

A computer algorithm was written to synthesize candidate cycles by stringing together the 833 micro-trips, the idle to idle driving events collected during the chase car study, in a semi-random manner. Each candidate cycle was then compared to the overall SAFD to determine which cycle best represented L.A. driving overall.

The resulting cycle named the "Unified Cycle" or the "LA92", is approximately 10 miles in length, with an average speed of 24.8 miles per hour, a top speed of 67 miles per hour, 16.4 percent idle and 1.52 stops per mile.

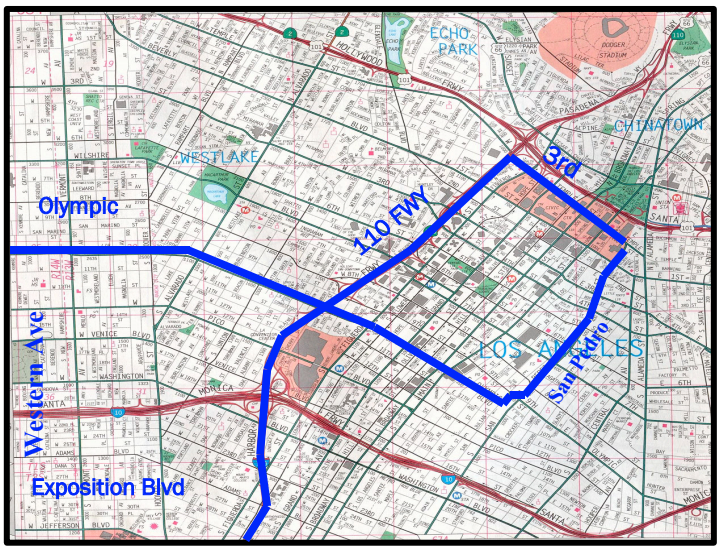
Vehicles tested over the LA92 were found to emit significantly higher compared to vehicles tested over the FTP.

Transitioning from the FTP to the UC marked a significant improvement in the representativeness of the on-road inventory.

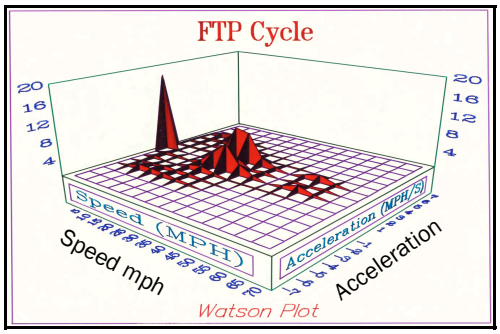
The map to the right displays "Los Angeles Route Four", (LA4) which was ultimately used to develop the FTP cycle.

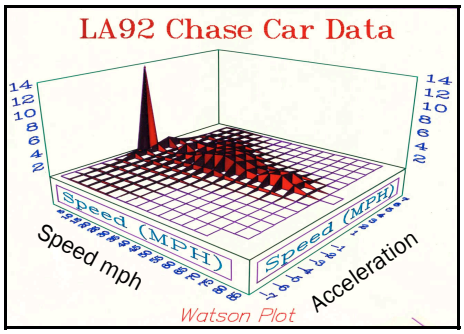
The route forms a figure "8" from and to the site of the predecessor of the Air Resources Board in downtown Los Angeles.

The direction of travel was northwest on third to the 110 freeway, the 110 south to Exposition Boulevard, west to Western Avenue, north to Olympic Boulevard east to San Pedro Street and finally north to Third Street.



Watson Plots of the FTP and LA92 Cycles
Speed Acceleration Frequency





Comparison of the LA4, the 1992 Chase Car Data, and the Unified Cycle

Parameter	LA4	Entire Data Set	UC / LA92
Average Speed	19.6 mph	26.6 mph	24.8 mph
Maximum Speed	56.7 mph	80.3 mph	67.0 mph
Avg Maximum Speed	N/A	55.8 mph	N/A
Percent Idle	19.0	14.4	16.4
Stops per Mile	2.41	1.26	1.52
Max Acceleration	1.48 m/s^2	3.62m/s^2	2.75 m/s^2
Avg Max Acceleration	N/A	2.55m/s^2	N/A
Cycle Length	7.5 miles	N/A	9.9 miles